

Case BENDE-008B  
Patent Application

5 TITLE OF INVENTION

SYSTEMS FOR SECURING SUTURES, GRAFTS AND SOFT  
TISSUE TO BONE AND PERIOSTEUM

10 CROSS-REFERENCE TO RELATED APPLICATIONS

The following patent application is a continuation-in-part  
of United States Patent Application Serial No. 09/197,938  
entitled Systems for Securing Sutures, Grafts and Soft Tissue to  
15 Bone and Periosteum, now in the issuance process, and further  
relies upon Disclosure Document No. 463,908 entitled  
Transvaginal Rectus-Fascia Anchor, filed October 21, 1999;  
Disclosure Document No. 479243 entitled Adjustable Soft Tissue  
Attachment Device and System, filed September 5, 2000;  
20 Disclosure Document entitled Transvaginal Rectus-Fascia  
Attachment, filed March 1, 2000, disclosure document number not  
assigned; Disclosure Document entitled Transvaginal Attachment  
Delivery Tool, filed on or about March 1, 2000, disclosure  
document number not assigned; Disclosure Document No. 463,825  
25 entitled Transvaginal Anchor Delivery Tool, filed on October 21,  
1999; Disclosure Document No. 458,659 entitled Transvaginal  
Adjustable System, filed July 6, 1999; and Disclosure Document  
No. 480,805 entitled Adjustable Suture Soft Tissue Attachment  
System, filed October 6, 2000, the teachings of all of which are  
30 incorporated herein by reference.

STATEMENT RE: FEDERALLY SPONSORED RESEARCH/DEVELOPMENT  
(Not applicable)

# BACKGROUND OF THE INVENTION

The use of surgical suture anchors for use in attaching soft tissue to bone is well known in the art. In this regard, such anchoring mechanisms have found widespread applicability for a number of surgical procedures, and in particular orthopedic, gynecologic and urologic procedures. Exemplary of such devices include bone screws or anchors that are implantable within bone which further have formed thereon an eyelet or other type of assembly to which may be affixed suture lines or a segment of soft tissue. Exemplary of such devices include those devices disclosed in United States Patents No. 5,370,662 and 5,443,482 to Stone, et al. and United States Patent No. 4,738,255 to Gobel, et al.

Generally, prior art anchor systems take one of two forms. The first configuration typically comprises a self-tapping bone screw, typically made of titanium, having an eyelet formed thereon to which the sutures or other material may be attached. In the alternative prior art configuration, the device comprises an anchor member, which may take the form of an arrowhead or similar conical configuration, which further includes a shaft or attachment member extending therefrom, the latter being formed to have one or more apertures to which the sutures or other material may be attached.

With respect to the surgical installation of such devices, bone-screw mechanisms must necessarily be screwed in position, typically by a battery-powered screw driver, at a target site upon a particular bone. Anchor devices of the other aforementioned variety typically must be "shot" into position at a particular site within a bone, typically via a spring-loaded delivery mechanism. Exemplary of such bone-anchor insertion devices include the In-Fast and In-Tac bone screw and bone anchor fixation devices previously produced by Influence, Inc.

of San Francisco, California, now a division of American Medical Systems, Inc.

Although such prior art anchor devices generally provide sufficient support to the various sutures and grafts affixed thereto, such fixation devices suffer from numerous drawbacks. In this regard, it is difficult for the surgeon to accurately deploy the insertion device such that the anchor is correctly inserted at the target site. Moreover, substantial difficulty arises in removing and adjusting such devices. This latter task is especially problematic with respect to bone-screw devices insofar as the surgeon attempting to remove the same must take great care to insure that the removal device, also typically comprising a battery-powered screw driver, properly unscrews the anchor member from its seated position. Other prior art anchor devices are even further problematic insofar as the same are often irretrievable once deployed, especially in situations where the same are deployed too deeply into the bone mass.

Additional problems exist with prior art bone fixation systems insofar as the same have a tendency to become dislodged over time from their seated position. In this regard, due to the repetitive application of stress or strain upon the bone anchor via the suture or soft tissue attached thereto, such anchors can eventually become loose and slip out of engagement from their fixed position. This tendency is especially likely to the extent repetitive and persistent application of strain and stress is applied in one specific direction or orientation. Moreover, even to the extent such bone anchoring systems remain securely in position, recent research tends to indicate that such bone fixation devices have a tendency to actually cut the sutures sought to be held thereby.

Separate and apart from the drawbacks associated with the use of prior art bone anchoring systems is the fact that often times anchor systems provide far more structural support than is

necessary for a given surgical application. In this respect, numerous surgical procedures requiring the fixation of sutures and/or soft tissue require only a minimal degree of tension. Exemplary of, and perhaps most well-known of such procedures

5 include transvaginal sling surgery to treat incontinence, which essentially involves the formation of a graft positioned beneath the urethra with the opposed ends thereof being secured to either one of the abdominal fascia, Cooper's ligament or pubic bone. While such slings typically require little to no tension

10 once fixed into position, due to the lack of alternative means for affixing the opposed ends of such sling into position relative to the pubic bone, such prior art bone anchor devices must necessarily be deployed. As a result, operative time is increased and the patient undergoing such procedures is

15 subjected to a far more traumatic experience and has a possibly greater susceptibility of becoming infected by virtue of the deployment of such anchor devices than would otherwise occur to the extent alternative, less traumatic affixation devices could be deployed.

20 Accordingly, there is a need in the art for systems and devices for affixing sutures, grafts, soft tissues, synthetic materials, and the like to bone that are easier to deploy, remove and can remain more firmly seated into position than prior art devices. There is additionally a need for such

25 devices that can be utilized in a wide variety of surgical applications and may be further customized for use for particular applications such that an optimal degree of support or leverage can be provided thereby. There is further a need in the art for affixation systems and devices that can provide for

30 means for affixing sutures, grafts, soft tissues, synthetic materials, and the like into position that are less traumatic, easier to deploy and adjust, and may be readily removed and

repositioned at a particular site than prior art systems and devices.

#### SUMMARY OF THE INVENTION

5           The present invention specifically addresses and alleviates the above-identified deficiencies in the art. In this regard, the present invention is directed to novel devices for the attachment of sutures, grafts and other types of tissues and materials to bone, periosteum, ligaments, fascia and other  
10 soft tissue as may be warranted in a given surgical procedure. The devices of the present invention are particularly well suited for the attachment of one or both of the opposed ends of a suburethral sling for use in suburethral sling surgery, but are by no means limited to such particular application.

15           In a first preferred embodiment, the invention comprises an implant implantable within bone, ligaments, fascia and other soft tissue at a desired location. The implant comprises a piton portion designed to pierce into and engage with the bone, or tissue, and a support structure coupled therewith, the latter  
20 of which may take the form of a post, hook or eyelet to which the suture, graft, or tissue may be attached. The implants of the present invention may further include a handle member formed thereon to facilitate the insertion and removal of the implant from its fixed or seated position within the bone/tissue.

25           The piton portion of the implant is specifically designed to become more firmly embedded within the bone or other tissue when pressure is applied to the support structure in a first direction, but may be dislodged or removed when the implant is pulled in an opposed or second direction. The piton member may  
30 be further selectively sized and adapted for use in a particular application, and may be particularly designed to penetrate up to certain depths and/or be capable of supporting a specific quantity of mass or weight. In this regard, the implants may be

designed to have two or more piton members, that each respectively provide means for securely attaching such implant to a desired side. Such implants may be further configured such that multiple implants may be deployed upon a length of a  
5 suture, such that the suture may be selectively pulled and anchored into position along a desired pathway. In this respect, the piton members may be formed such that the same are operative to facilitate movement through tissue in one direction, yet perform an anchoring function in an opposite  
10 direction.

Such embodiment further advantageously allows for post-operative adjustment whereby the suture with piton members attached thereto can be selectively pulled along the desired pathway to the extent necessary to adjust the suture position  
15 and/or introduce a greater degree of tension thereto. Along these lines, such embodiment has the additional advantage of being completely removable from the patient's body by virtue of its ability to selectively move through and out of tissue.

In a second preferred embodiment, the invention comprises  
20 a disc anchoring system that is operative to serve as a platform to which sutures, graphs and the like may be secured or, alternatively, serve as a support for forming a suture "bridge". According to one preferred version, the affixation device comprises a disc or anchor plate which is positionable upon a  
25 layer of tissue, such as a layer of muscle, fascia, or ligament, and in particular, the rectus fascia layer. The anchoring plate is preferably formed to be generally circular in nature and comprised of an inner plate member encased within an annular outer plate member. The inner and outer plate members are  
30 further preferably formed such that at least one, and preferably two, diametrically opposed apertures are formed respectively therein for receiving suture lines insertable therethrough. The inner plate and outer annular member are formed relative one

another such that the inner plate is rotational relative the  
outer annular ring and operative to transition between a first  
open configuration, wherein said apertures formed upon the  
respective plates are open to receive suture lines therethrough  
5 and a second closed configuration, wherein rotation of the inner  
plate relative to the annular ring causes the apertures to close  
and lock, (i.e., crimp) any suture line extending therethrough  
to become rigidly secured in position. To the extent desired,  
those portions of the sutures extending through the anchor plate  
10 may be affixed to one another to thus form a bridge or adjoining  
suture link.

In an alternative configuration, the disc anchoring system  
comprises as disc or anchor plate which is likewise positionable  
upon a layer of tissue (e.g., muscle, fascia, or ligament) that  
15 includes at least one, and preferably two to four, channels for  
receiving suture lines insertable therethrough. The channel or  
channels are configured such that the same are crimpable such  
that when the suture line or lines are ideally positioned  
therein or impart the necessary degree of support to an object  
20 (i.e., sling, graft, etc.), the crimping of such channel or  
channels affixes such length of suture or sutures into position.  
To achieve that end, it is contemplated that any of a variety of  
conventional crimping devices may be deployed to impart the  
necessary crimp in the channel or channels. As per the  
25 aforementioned embodiment, to the extent multiple suture lines  
extend through such plate, the same may be tied, linked, crimped  
or otherwise joined to one another to form a suture bridge.

The disc anchoring system may further take the form of a  
system whereby a suture, having a plurality of protuberances  
30 formed therealong, is engageable with an anchor plate, the latter  
having an aperture formed therein for receiving the suture line.  
As respective ones of the protuberances extend through and rest  
against the anchor plate, the suture line may thus be maintained

in a fixed position relative a desired target site. Such embodiment advantageously provides for post-operative adjustment should it become necessary to reposition the suture or increase the tension within the suture line secured by the disc anchoring system.

In all embodiments, the disc anchoring systems are particularly well suited for the use in pubovaginal sling surgery where it is necessary to secure a sling such that the sling extends a desired distance from the urethra or exerts a desired degree of supportive pressure thereto, which thus necessitates that such sling be selectively secured into position via the suture extending through the anchor plate. It will be recognized, however, that such disc anchoring systems may be utilized for a wide variety of medical applications and further, may be formed to be permanently affixed into position or formed from a bio-absorbable material to the extent such anchoring systems need only remain resident for a limited duration. Still further, it is contemplated that each of the aforementioned disc anchoring system may incorporate a load-bearing object, such as a washer, mesh or other like structure, as part of or in conjunction with the disc anchoring system to facilitate the distribution of stress and strain imparted thereto. As with the disc system, such load distributing apparatus may be formed to be permanently secured into position or formed from an absorbable material.

In a third preferred embodiment, the invention comprises an affixation device designed to secure sutures, grafts, tissues, synthetic materials, and the like to periosteum (i.e., the thick fibrous membrane covering the surface of bones) and other soft tissue. According to a preferred embodiment, the affixation device includes a backing or base member having at least one, and preferably a multiplicity of hook members that are sized and adapted to hook into and ensnare with the



periosteum or tissue. The hook members may be specifically designed to become partially embedded within the periosteum tissue, to thus provide relatively loose connection that is easier to remove, or adjust, and may be designed to penetrate  
5 deeper within the periosteum tissue to thus provide a more secure method of attachment. An attachment member formed upon the base member is further provided to which may be attached a suture or a portion of a graft.

In an alternative preferred embodiment, the invention  
10 comprises an implantable tack consisting of a hub member having at least one, and preferably two or more hook members formed thereon, the latter being designed to extend through the graft or tissue and become ensnared with and embedded in the periosteum such that the graft or tissue becomes interposed  
15 between and affixed into position relative the tack and periosteum. The affixation devices according to such embodiments are specifically designed for selective attachment and detachment, and are further designed to provide more atraumatic means for the attachment of the suture or graft to a  
20 target location via the periosteum and soft tissue. Such a fixation devices, however, may be adapted such that the same are designed to pierce into and become embedded within the bone, as per the other aforementioned embodiments.

In yet another embodiment of the present invention, there  
25 is provided a novel surgical staple that is also designed to secure a graft or other types of tissues and materials to the bone, periosteum, or other soft tissue at a specific site or location. The staples of the present invention are preferably formed from plastically deformable materials having opposed ends  
30 that are designed to penetrate through the graft/tissue and hook into the bone, periosteum or soft tissue at a selected site of fixation. Once secured in position, the staples are operative to assume an expanded configuration such that the hooks formed

thereby become more firmly embedded within the bone/tissue at the target site of fixation to thus further secure attachment of the graft thereto. Preferably, such staples may be fabricated from a shape-memory material, such as nitinol, which thus enables the staple to assume the compressed configuration when at room temperature, but transition to the operative, expanded configuration when warmed to body temperature, as will occur when the device is deployed. Such materials further enable the staples of the present invention to be removed, as may be necessary, during a given procedure or later procedures. Conversely, such staples may be formed from material that enable the same to compress or contract once secured into position to thus provide for a more secure means of attachment.

The present invention further comprises novel surgical approaches for the affixation of a transvaginal sling during transvaginal sling surgery. More particularly, such surgical procedure involves securing such sling into position, namely, beneath the urethra, with the opposed ends thereof being secured to the posterior portion of the pubic bone, whether it be either the pubic bone itself or the periosteum surrounding the same, in the retropubic space. The opposed ends of the sling may be attached to either the periosteum over the pubic bone or to the pubic bone itself using the novel affixation devices of the present invention. Advantageously, such surgical procedure eliminates the needs to form a abdominal incision, which typically must be made utilizing conventional surgical procedures. The novel affixation method of the present invention during such surgery further provides for the ingrowth of the opposed ends of the graft to a target site near or at on the pubic bone or the periosteum thereabout that eliminates any intervening pelvic fascia that would otherwise become interposed between the anchor and opposed ends of the sling sought to be secured into position.

It is therefore an option of the present invention to provide surgical implantation devices to facilitate the attachment of sutures, grafts, tissues and the like to bone, periosteum and soft tissue that are easier to implant and remove than prior art devices, and are further capable of providing greater support or leverage to the structures coupled therewith than prior art devices.

Another object of the present invention is to provide surgical implantation devices for the attachment of sutures, grafts, tissues and the like to bone, periosteum and soft tissue that can be utilized in a wide variety of surgical procedures, and in particular suburethral sling surgery, and that may be further designed to provide an optimal degree of support for a given quantity of mass or weight as may be necessary for a given surgical procedure. Another object of the present invention is to provide devices for the affixation of sutures, grafts, tissues and the like to periosteum and soft tissue at a specific site or location that does not require any anchoring mechanism to be inserted into the bone.

Another object of the present invention is to provide devices for the attachment of sutures, grafts, tissues and the like to bone, periosteum and soft tissue at a specific location that are less traumatic than other prior art affixation devices.

Another object of the present invention is to provide devices for the attachment of sutures, grafts, tissues and the like to bone, periosteum and soft tissue at a specific location that are easily attachable to and detachable from a point of fixation than prior art devices and re-attachable as may be necessary for a given procedure or future procedures.

Still further objects of the invention include methods and devices for securing sutures, grafts, tissues and the like to bone, periosteum and soft tissue that are of simple construction, may be easily and readily utilized for a variety

of surgical procedures, may be readily adapted for use in a wide variety of surgical procedures, and provide an equal, if not greater degree of support or leverage than prior art devices. It is additionally an object of the present invention to provide  
5 a novel surgical procedure for the formation and affixation of a suburethral sling whereby the opposed ends of the sling are secured near or at the posterior side of the pubic bone in the retropubic space with the opposed ends of the sling being secured to either the periosteum, Cooper's ligament, fascia or  
10 the pubic bone itself.

#### BRIEF DESCRIPTION OF THE DRAWINGS

These, as well as other features of the present invention will become more apparent upon reference to the drawings  
15 wherein:

Figure 1 is a frontal, cross-sectional view of the rectus fascia, pubic bone, urethra and vagina further depicting a sling member positioned about the urethra or in which the respective ones of opposed ends of the sling are secured to the pubic bone.

20 Figure 2 is a side cross-sectional view of the anatomical structures depicted in Figure 1 and further depicting the fastening arrangement by which the sling is anchored to the posterior portion of the pubic bone.

Figure 3 is a prior art surgical instrument utilized to  
25 secure the anchor member depicted in Figure 2 to the posterior of the pubic bone.

Figure 4 is cross-sectional view of the pubic bone having a prior art anchor device secured thereto.

Figures 5(a) and (b) are perspective views of prior art  
30 anchor devices.

Figure 6 and 6(a) are a perspective view of a surgical implant constructed in accordance with a preferred embodiment of the present invention for use in attaching sutures, grafts,

tissues and the like to bone, periosteum, and soft tissue, and a side view of the same being inserted into bone.

Figure 7(a) is a perspective view of a surgical implant constructed in accordance with a second preferred embodiment of the present invention for use in attaching sutures, grafts, tissues and the like to bone, periosteum, and soft tissue. Such figure depicts the surgical implant assuming a pre-insertion configuration.

Figure 7(b) is a perspective view of the surgical implant of Figure 7(a) with the implant assuming an expanded, anchoring configuration.

Figure 8 is a perspective view of a surgical implant constructed in accordance with a third preferred embodiment of the present invention for use in attaching sutures, grafts, tissues and the like to bone, periosteum, and soft tissue.

Figure 9 is a cross-sectional view of the pubic bone and periosteum thereof having an affixation device affixed with the latter, said affixation device being constructed in accordance with a fourth preferred embodiment of the present invention useful for securing sutures, grafts, tissues and the like to bone, periosteum and soft tissue.

Figure 10 is a perspective view of the affixation device depicted in Figure 9.

Figure 11 is a cross-sectional view of the pubic bone and periosteum formed thereabout having an opposed end of a graft being secured thereto with an implantable tack, the latter being constructed in accordance with a fifth preferred embodiment of the present invention.

Figure 12 is a cross-sectional view of the pubic bone and periosteum formed thereabout showing the graft depicted in Figure 11 being secured thereto via the implantable tack.

Figure 13 is frontal view of the graft depicted in Figures 11 and 12 as secured to the periosteum via the implantable tack of the present invention.

Figure 14 is a cross-sectional view further depicting an expanded view of the pubic bone with periosteum formed thereabout having an opposed end of the surgical sling affixed to the periosteum via a surgical staple, the latter being constructed in accordance with a sixth preferred embodiment of the present invention, the staple assuming a first insertion mode.

Figure 15 is a side-view depicting the surgical staple depicted in Figure 14 securing an opposed end of the sling to the periosteum, the staple assuming a second, affixation configuration.

Figure 16 is a cross-sectional view of suture having a plurality of affixation devices secured thereto, the latter constructed in accordance with a preferred embodiment of the present invention, for use in securing the suture along a desired pathway through tissue.

Figure 16a is perspective side view of figure 16.

Figure 17 is a frontal, partially cross-sectional view of a sling being secured beneath a urethra and selectively secured in position to layers of muscle/rectus fascia via an anchoring plate fixation device as constructed in accordance to the preferred embodiment of the present invention.

Figures 17a and 17b are top views of the fixation device utilized in Figure 17, the fixation device being shown in a first operative configuration in a second locking or closed configuration.

Figure 18 is perspective view of an anchoring system constructed in accordance with another preferred embodiment of the present invention.

Figure 19 is a perspective view of an anchoring system constructed in accordance with another preferred embodiment of the present invention.

Figure 19a is a partial cross-sectional view of the system depicted in Figure 19 shown with a suture line extending through a channel defined thereby.

Figure 19b is the cross-sectional view of Figure 19a wherein the channel of said anchoring system is shown in a crimped configuration, the crimp maintaining the suture disposed within the channel in fixed position.

Figure 19c is a cross-sectional view of the anchoring system depicted in Figure 19 with one channel extending therethrough, said channel having two suture lines extended therethrough.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The detailed description as set forth below in connection with the appended drawings is intended as a description of the presently preferred embodiments of the invention, and is not intended to represent the only form in which the present invention may be constructed or utilized. The description sets forth the functions and sequences of steps for constructing and operating the invention in connection with the illustrated embodiments. It is understood, however, that the same or equivalent functions and sequences may be accomplished by different embodiments and that they are also intended to be encompassed within the scope of this invention.

Referring now to the drawings, and particularly Figures 6-15, there are shown various embodiments of the devices and systems of the present invention for securing sutures, grafts, tissues and synthetic materials, and the like to bone, periosteum and other soft tissue. As is well known in the practice of medicine, a wide variety of surgical procedures

often necessitate the use of anchoring devices for purposes of attaching suture lines and grafts to bone. Exemplary of such anchoring devices include those disclosed in United States Patent Registration Nos. 5,370,662 and 5,443,482, the teachings  
5 of which are expressly incorporated herein by reference as frequently deployed in orthopedic, gynecologic, and urologic surgical procedures.

Among the more well-known surgical procedures incorporating the use of such anchoring devices include  
10 transvaginal sling surgery. As illustrated in Figures 1 and 2, such surgical procedure 10 involves the formation of a sling 12, which may comprise a harvested graft from a donor, or the patient's own tissue or an elongate strip of fabricated synthetic material, that is introduced via an opening made to  
15 the vaginal wall 14 and selectively positioned beneath the urethra 16. Once properly positioned, the sling 12 is secured into position. Unlike conventional transvaginal sling surgery, however, the sling 12 as depicted in Figures 1 and 2 is secured within the retropubic space via an anchoring mechanism 20, more  
20 clearly depicted in Figure 2. As will be appreciated by those skilled in the art, the method by which the opposed ends 12a, 12b of the sling 12 are secured, namely to the posterior side of the pubic bone 18, represents a novel approach insofar as such sling 12 is stitched into position in the retropubic space 22,  
25 as opposed to the suprapubic space which is conventionally utilized. Unlike alternative methods of performing suburethral sling procedures, such transvaginal sling surgical procedure advantageously dispenses with the need to form an incision in the patient's lower abdomen 24 to thus enable the surgeon to  
30 gain access to the various anatomical structures, such as the abdominal fascia, pubic bone, or Cooper's ligament, to which the opposed ends of such sling are to be attached. As is well known, performing such abdominal incision increases operative



time, increases the chances of infection, delays recovery time, and leaves undesirable scarring. Moreover, such sling procedure as depicted does not require that the sutures or opposed ends of the grafts be caused to penetrate through the intervening pubocervical fascia 28, depicted in Figure 1, present in the retropubic space 22 which, as will be appreciated by those skilled in the art, prevents ingrowth of the opposed ends 12a, 12b of the sling 12 sought to be secured in position.

As a result of the support imparted by the sling 12 to the urethra 16 during such times as the patient makes provocative gestures, as occurs during coughing, such sling 12 serves as a support that prevents incontinence occurring during such provocative event. To insure that the sling 12 is positioned such that the same imparts an optimal degree of support to the urethra 16, it is contemplated that a tension/pressure monitor 26, as depicted in Figure 1, may be utilized during the performance of such surgical procedure. Such tension/pressure monitors 26 may take any of a variety of forms such as those disclosed in Applicant's co-pending United States Patent Application Serial No. 09/157,466, the teachings of which are expressly incorporated herein by reference.

In order to provide an anchoring mechanism necessary to secure the sling into position during transvaginal sling procedures, however, there must be deployed the aforementioned anchoring device 20. As depicted in Figure 3, there is shown one such anchor deployment device 30, also known in the practice of medicine as a bone screw inserter, which allows for bone-screw fixation. Perhaps the most well-known of such devices include the In-Fast and In-Tac bone screw and bone anchor fixation devices previously produced by Influence, Inc. of San Francisco, California. Such affixation devices are formed to have a generally "U" shape as shown that enables the distal-most end 32 thereof to be easily inserted into the vagina and be

correctly positioned on the posterior portion of the pubic bone. As will be appreciated by those skilled in the art, the distal-most end 32 of such fixation deployment devices 30 are designed to deploy an anchoring device by screwing or embedding the same into bone at a specific site.

As more clearly seen in Figure 4, once deployed, the anchor devices 34 are advanced through the periosteum 36 and become embedded into the bone. To provide means for affixing the suture lines or grafts thereto, there is typically formed on the anchor devices a post, hook or eyelet, as shown. Among the more well-known designs of such anchoring devices currently in use include those depicted in Figures 5(a) and (b). The first such prior art device 34 depicted in Figure 5(a) comprises a self-tapping bone screw 40, typically made of titanium, having an eyelet 42 formed thereon to which the sutures 44 or other material may be attached, as shown in Figure 4. In the alternative prior art configuration 50 depicted in Figure 5(b), the anchor fixation device comprises an anchor portion 52, which may take the form of a conical member having a shaft or attachment member 54 extending therefrom, the latter being formed to have one or more apertures 56 thereon to which sutures 58 or other material may be attached. Such devices are typically "shot" into position via spring-loaded insertion devices, such as the In-Tac device discussed above.

Although such prior art anchor devices, such as those depicted in Figures 5(a) and (b), generally provide sufficient support to the various sutures and grafts affixed thereto, such fixation devices 34, 50 suffer from numerous drawbacks. With respect to the bone-screw fixation devices 34, such devices are difficult to deploy and fix into position. In this regard, such screw fixation devices 34 require the battery-operated inserters 30 depicted in Figure 3 that must necessarily drill the fixation device 34 into position. Removing such devices 34 is further

problematic insofar as the same must necessarily be unscrewed from their position, which as those skilled in the art will appreciate requires meticulous precision.

Anchor devices 50 are also problematic insofar as the same are not only difficult to deploy, typically via a spring-loaded gun mechanism, but are often times irretrievable-able once deployed. In this regard, once such fixation device 50 is sufficiently embedded within the bone, the anchor portion 52 thereof cannot be reversibly extracted from its embedded position within the bone. As such, to the extent such anchoring devices 50 have been inappropriately deployed (e.g., deployed at a wrong location), there is little, if any, recourse to retrieve the same. Additionally, such prior art bone screws 34 and anchors 50 have the ability to become loosened and dislodged from their position once a sufficient amount of pressure is applied thereto over time. The probability of becoming dislodged is further increased in those situations where a persistent strain is applied to such devices in a single direction, as can occur when a suture or graft is hung upon the anchoring device. In such circumstances, surgical intervention is necessary to not only retrieve the dislodged screw or anchor, but also deploy yet another of such devices as per the original surgical procedure.

Referring now to Figures 6-8, there are shown three embodiments 60, 70, 80 of a surgical implant insertable into bone (as well as periosteum, ligaments, and other soft tissue) which are useful in providing means to secure sutures, grafts, tissues, synthetic materials, and the like to bone, as may be necessary for a given surgical procedure. Each of the embodiments depicted have the advantage of being easy to insert and remove, as well as provide an equal, if not greater, degree of support than prior art devices. Such novel implants further

have the ability to remain more firmly seated into position once embedded in bone than such prior art devices.

Referring now to Figure 6, there is shown a first embodiment 60 of the surgical implant. As illustrated, the implant 60 comprises a piton member 62 having an eyelet 64 formed thereon. The piton member 62 preferably comprises an arcuate blade having proximal and distal ends, the latter being designed to be inserted into bone such that as the same is advanced therein, there is defined a penetration pathway as indicated by the letter "A". Once inserted into the bone tissue at the target site of fixation, the eyelet portion 64 of the implant will extend therefrom as illustrated in Figure 6(a), which will thus provide the necessary structure to which the sutures 66, grafts and the like may be attached. Although the embodiment shown depicts the use of an eyelet 64, it will be recognized that other substitute support or attachment structures, such as posts, hooks and the like, including even sledged-on fixation of the suture or graft to the piton, may be utilized as may be necessary for a given application.

As will be appreciated by those skilled in the art, by inserting the implant in the direction indicated by the letter "A", it will be appreciated that to the extent a force is applied thereto, such as by suture 60 or graft, via a vector having an orientation in the general direction of letter "B", such force will necessarily cause the implant to wedge deeper and become more secure into position within the bone 38, and will thus cause the same to become more rigidly affixed into position, unlike prior art devices which have a tendency to become loose and potentially dislodged with the application of greater amounts of pressure and strain thereto.

Such implant further provides the advantage of being easy to remove. In this regard, due to its orientation within the bone, to the extent a pulling force is applied to the implant in

the direction indicated by the letter "C", such implant 60 will be caused to become easily dislodged from its seated position to the extent it becomes necessary to remove and/or reposition such implantable fixation device. Such ease of removal advantageously provides for a simpler, less traumatic procedure than those procedures involving prior art screw and anchor fixation devices.

Referring now to Figures 7(a) and 7(b), there is shown a second embodiment 70 of a surgical implant designed to be embedded within bone or soft tissue to which may be attached sutures, grafts and the like. Such embodiment 50, similar to the embodiment 60 depicted in Figure 6, is specifically designed such that the same becomes more firmly seated into position within the bone to the extent a force is applied in a first direction, as indicated by the letter "D". Figure 7(a) depicts the surgical implant 70 assuming an insertion configuration which enables the same to be implanted into bone at a target site selected by the surgeon. Such implant is provided with a piton member 72 having opposed flanges 72a, 72b formed at the distal end thereof that are designed to spread apart in the directions Y and Z and become more deeply embedded within the bone to the extent a pressure is applied in a direction indicated by the letter "D". Although the specific embodiment 70 shown depicts that the opposed flanges 72a, 72b flare outwardly, it is to be understood that such flanges can be designed to curve inwardly. Moreover, although such embodiment depicts two opposed flanges, it should be recognized that such implant may have three or more flanges and that each respective flange may be designed to flare outwardly, as shown, or hook inwardly as may be needed to a specific application.

Once firmly embedded within the bone, the eyelet portion 74 of such implant may be utilized to attach sutures and the like. Of additional advantage, similar to the embodiment shown

in Figure 6, is the fact that such implant 70 may further be easily removed to the extent a pulling or opposed force is applied in the direction indicated by the letter "E". As such, to the extent it becomes necessary to remove or otherwise  
5 reposition such anchoring device, such anchoring device 70 may be easily dislodged by application of such force. As will be appreciated, such design allows for easier and less traumatic removal than prior art anchor and screw fixation devices.

Referring now to Figure 8, there is shown a third  
10 embodiment 80 of a surgical tissue implant useful as a fixation device to attach sutures, tissues, and grafts to bone, periosteum, and soft tissue. As per the other embodiments, such implant 80 includes a piton member 82, preferably formed as a sickle-shaped member, having an eyelet 84 formed on the proximal  
15 end thereof. Such implant 80 is designed to be embedded into the bone or other tissue in the direction indicated by the letter "F". Once so secured into position, forces may be applied thereto, via eyelet 84 in the direction indicated by the letter "G", which will thus work to further embed the piton  
20 member 82 into the bone via the penetration pathway defined by the distal end of the piton member 82 so that the implant becomes more secure therewithin. Likewise, to the extent it becomes necessary to remove such device 80, such device may be removed by pulling or otherwise rearwardly retracting the  
25 implant in the direction indicated by the letter "H" which, as discussed in the other embodiments, provides for simpler and less traumatic procedure than prior art methodology.

Although each of the aforementioned embodiments 60, 70, 80  
30 are particularly well-suited for insertion into bone, it should be recognized by those skilled in the art that the same may be utilized to affix sutures, grafts, tissues, synthetic materials and the like to connective tissue, and in particular, periosteum as per the further embodiments discussed more fully below. In

this respect, each of the aforementioned embodiments 60, 70, 80 may be designed such that the piton portion thereof pierces into and becomes embedded within such tissue and remains firmly seated thereat so that the attachment mechanism formed thereon  
5 can provide a service to which the sutures, grafts and the like may be attached.

As will further be appreciated, in each of the embodiments 60, 70, 80 depicted in Figures 6-8, the orientation of each of the implants as the same are embedded into the bone or tissue is  
10 crucial for the necessary operation thereof. In this regard, it will be appreciated that the implant must be oriented such that the resultant tension or strain applied thereto will cause the piton portion thereof to advance in the penetration pathway defined thereby. Otherwise, to the extent tension is applied in  
15 an opposed direction, such implant may be caused to dislodge from its seated position. As a consequence, it will be appreciated that the implants of the present invention must be selectively positioned, and that the surgeon must take great care in making certain that the ultimate tension applied thereto  
20 is oriented to facilitate the attachment of the implant to the bone, as opposed to causing the same to become dislodged therefrom.

Referring now to drawings 16 and 16a, there is shown an additional surgical tissue implant 500 useful as a fixation  
25 mechanism to attach sutures, tissues, and grafts to soft tissue. In the embodiment depicted, which is shown being deployed for use in securing a sling 502 into position to provide support to a urethra 504, the implant 500 comprises a plurality of dual-prong anchoring mechanisms 506 disposed linearly about a suture-  
30 like cord or line 508, which enables such line to advance through the tissue in one direction, but resists rearward movement in the opposite direction. As shown, the implants can be configured to have a generally V-orientation such that the

suture 508 bisects such implant and extends therethrough. As will be recognized, each respective implant will have an eyelet or other aperture through which the suture, which may be a suture line or suture-like cord, may be extended. As will be further recognized, although depicted as having a generally V-orientation, it will be appreciated that the anchoring mechanisms 506 may be arranged in a staggered configuration, extend along only side of the suture 508, or otherwise be radially disposed about a length of the suture 508. Accordingly, it will be recognized that numerous other designs are contemplated that fall within the scope of the present invention.

By linearly disposing the implants along the suture line, the suture line may be advanced in a direction indicated by the letter X, but yet resist movement in the direction indicated by the letter Y. Advantageously, such arrangement enables the suture line 508 to be pulled into a desired position such that the sling 502 supported thereby can be caused to provide a selective degree of support to the urethra 504 or otherwise maintain a desired distance therefrom. Furthermore, to the extent the suture line 508 with implants 506 or the sling 502 supported thereby are inappropriately positioned, it will be recognized by those skilled in the art that, if necessary, the suture line 508 can be cut and the suture with implants affixed thereto extracted completely from the patient's body (and replaced, if necessary or desired). Such design further advantageously permits for the adjustment of the suture line and/or the sling supported thereby not only intra-operatively, but also post-operatively insofar as the suture line 508 can be extended further, for example, in the direction indicated by the letter X, as may be desired to the extent it is necessary to add extra tension to the suture line 508. Moreover, as discussed above, the suture line 508 can be removed entirely from a



patient's body. In such circumstances, a second suture line 508 having such implants attached can be substituted in its place.

An example of the application of such system is illustrated in the side-perspective view of Figure 16a. As illustrated, the sling 502 is positioned about the urethra 504 and supported upwardly by the suture-like cord 508 having the fixation devices 506 linearly disposed upon the length thereof. In this regard, each respective suture, cord, etc. 508 supporting each respective side of the sling 502 may be selectively caused to remain securely embedded at a desired position within the rectus fascia 510 or other soft tissue. As will be appreciated by those skilled in the art, due to the ability of the suture lines or suture-like cords 508 with the novel implant fixation devices 506 affixed thereto, the surgeon can incrementally increase the pressure exerted by the sling 502 against the urethra 504 or the distance by which the sling 502 extends from the urethra 504 merely by incrementally advancing the suture line/cord 508 through the rectus fascia 510. As will be appreciated, there has not hereto for been available any mechanism available which provides a surgeon with the ability to merely advance a suture through tissue and have the same remain firmly secured into position. Rather, and as discussed more fully in the background, surgeons have had to identify a target site to which such sling can be anchored and thereafter tie the same into position such that the sling maintains the desired degree of support or distance from the urethra. As is widely recognized, malposition of the sling has been deemed the cause for creating a significant problem and substantially high morbidity for those patients having undergone sling surgery.

Referring now to Figure 17, there is shown yet another embodiment of a device 600 for attaching sutures, grafts, tissues and the like into position in the human body. As illustrated, such embodiment comprises an anchoring disc or

plate 602 which may be secured to or rest upon an anatomical structure, and more particularly a layer of muscle 604 or rectus fascia 606 as shown. As illustrated, which again is in the context of securing a sling 502 into position such that the urethra 504 is supported thereby, suture lines or suture-like cords 508 on each opposed end of the sling 502 are secured by dedicated anchoring plates 602, the latter being supported by a layer of muscle and/or layer of rectus fascia. As shown, the anchoring plates 602 are operative to secure the suture lines 508 into position such that the same are allowed to selectively advance therethrough and remain secured in position thereby without requiring that the sutures 508 be tied (i.e., at the fascia level 606).

To achieve that, there is shown in Figures 17a and 17b the mechanism by which the anchoring plate 602 is operative to secure the suture lines 508 thereto. As shown in 17a, the anchoring plate 602 comprises the combination of a first inner plate member 610 having at least one, and preferably two diametrically opposed apertures 612 formed therein. Encased about the first plate member 610 is a second annular plate member 614 which also includes at least one preferably, and two apertures 616 formed therein, such apertures 616 being selectively alignable with the apertures 612 formed upon the first inner plate 610. The first inner plate member 610 is rotationally mounted within the outer anchoring plate member 614, such that the same is operative to transition between a first open configuration, wherein the apertures 612 of the first inner plate 610 are alignable with those formed on the outer annular plate 614, and a second closed configuration, as shown in Figure 17b, wherein the apertures formed on the inner and outer plates 612, 616, respectively, are not aligned with one another, such that a closure is formed.

In use, the anchoring plate 602 may be secured into position, via prongs or some other type of anchoring mechanism (not shown) to a desired site. Alternatively, it will be appreciated that such anchoring plate 602 may only need be placed on the rectus fascia and, as discussed more fully below, due to the downward force exerted upon the anchoring plate 602 via the sutures held thereby, such anchoring plate will be caused to remain resident at the desired deployment site. Once positioned, the inner and outer plate members 610, 614 are maintained in the first operative configuration such that the apertures 612, 616, respectively formed thereon form the opening or openings through such anchoring plate 602. The suture lines 508 may then be extended through apertures defined by the first and second plate members such that the sling 502 held thereby is maintained in a desired orientation or provides a desired degree of support to the urethra 504. Once so positioned, the inner and outer plate members 610, 614 are rotated relative one another such that second closed configuration is maintained, which thus serves to secure the suture lines 508 into position. To facilitate that end, a knob 618 or other turning mechanism formed upon the inner plate may be provided to facilitate the insertionability to secure the suture lines 508 into position. As discussed above, such design advantageously dispenses with the need to tie down the suture lines or cords at the fascia level. To the extent desired, such anchoring system further enables the suture lines, and more particularly the suture lines extending through the anchor plate, to be secured to one another to thus form a suture "bridge". As shown in phantom, each respective suture line extending through the anchor plate can be linked to one another as shown. To achieve that end, it will be appreciated that such suture lines may be either tied, fused, crimped, linked or joined to one another via any of a wide

variety of methods and devices well known to those skilled in the art.

Referring now to Figure 18, there is shown a further refinement of the system utilized to secure a suture line at  
5 desired location such that a sling, graft or other object supported thereby is maintained at a desired location. As illustrated, such system 640 comprises the combination of a suture-like cord 642 having a plurality of protuberances 644 formed therealong and an anchoring plate 646. The suture-like  
10 cord 642 with protuberances 644 is formed such in the same is extensible through tissue. As will be appreciated by those skilled in the art, attached to an opposed end of such suture-like cord 642 with protuberances 644 is a graft, sling 502 or some other object to be held thereby. The suture-like cord 642  
15 is extensible through the anchoring plate 646, the latter being secured at a desired target site, which may include a bone, periosteum, soft tissue, or a layer of rectus fascia 606 as shown. The suture 642 is extensible through such anchoring plates 646 such that respective ones of the protuberances 644  
20 engage with a locking aperture 648 formed on such plate 646. As illustrated, each respective protuberance 644 can be pulled through such aperture 648 and thereafter caused to lock the suture 642 into position. As will be appreciated, as the sutures 642 pull through the anchoring plate 646, the suture  
25 line 642 will become progressively shorter and thus raise the object (i.e., sling 502) held thereby to the desired location. Advantageously, such system accommodated movement in both directions, and by pulling the suture in the rearward direction can cause the suture to experience an increase in slack, which  
30 thus consequently can lower or lessen the tension in the object supported thereby. As per the embodiment depicted in Figure 17, these suture-like cords with protuberances, to the extent multiple cords are utilized, may be linked to one another to

thus form a suture bridge, as may be desired for certain applications.

Referring now to Figures 19-19c, and initially to Figure 19, there is shown an additional embodiment 700 of an anchoring system for securing a suture-like cord or line 508 at a desired location. As per the embodiments depicted in Figures 17 and 18, the embodiment shown includes an anchor plate 702 having at least one, and preferably two to four, channels 704 extending therethrough for receiving suture-like cords 508. As per the aforementioned embodiments, the anchor plate 702 may likewise be secured into position with a fastener mechanism or, alternatively, merely be positioned at a desired site upon fascia or soft tissue with the ultimate tension imparted thereto by the sutures 508 held thereby causing the same to remain resident at such site.

As to the embodiment shown, the anchoring plate 702, once positioned, is operative to receive the suture line or lines 508 through the channels 704 defined thereby. As more clearly illustrated in the cross-sectional view of Figure 19a, the suture-like cord 508 can be pulled upwardly or downwardly until the same attains the desired position and/or imparts the desired tension to an object held thereby. Once such proper position and/or tension is attained, the channel 704 within which the suture-like cord 508 is disposed may be crimped, as depicted in Figure 19b, such that the suture line 508 is compressively held thereby. As will be appreciated by those skilled in the art, the channel 704 defined by the anchor plate 702 will be formed from a suitable deformable material well-known to those skilled in the art which can not only be easily crimped, but once so crimped, will impart the necessary compressive force to hold the suture 508 in position. It will likewise be recognized that the crimp made to the channel 704 may be formed by any of a variety

of surgical crimping mechanisms well-known and commercially available.

In an alternative configuration depicted in Figure 19c, the anchor plate 710 is designed such that the same only has one channel 712 formed therethrough through which one or more suture-like cords 508 may be received. As may be desired for certain procedures, particularly where it is advantageous to simplify such procedures, the channel 712 defined in the anchor plate 710 will preferably be centrally disposed upon the anchor plate such that the same is adapted to receive multiple suture-like cords therethrough (e.g., four (4) suture lines to accomodate two (2) opposed ends of a sling). Once the cord or cords 508 have been received therethrough and optimally positioned, the channel 712 may be crimped such that the cords are compressively held as desired. Any length of the sutures extending therethrough may be linked or connected to one another to thus form a suture bridge, which is again in phantom in Figure 19.

As will be recognized by those skilled in the art, by providing such a simplistic, atraumatic mechanism for securing sutures, grafts and the like into position substantially reduces suture erosion, greatly minimizes operative time, patient recovery time and further minimizes the risk of infection by minimizing the degree of invasiveness typically associated with securing slings and the like into an optimal position.

As will further be readily appreciated by those skilled in the art, the aforementioned anchoring systems, particularly those mechanisms depicted in Figures 17-19c, such may be formed from a bio-absorbable material, such that the anchoring system becomes absorbed over time. As will be appreciated by those skilled in the art, to the extent the anchoring system is fabricated to become absorbed over time, the aforementioned discussion regarding the suture bridge may be deemed optimal

should it become necessary to maintain the suture lines at a desired location following absorption of such anchoring system.

Alternatively, the anchoring systems may be formed from a non-absorbable material such that the same remains permanently  
5 embedded within the body. Moreover, it will be recognized that those mechanisms depicted in Figures 17-19c may further incorporate a tension spreading mechanism, such a washer or mesh of fabric, that may be deployed with or integrated as part of such anchoring system. In this respect, it will be appreciated  
10 that due to the fact that the suture holding mechanisms depicted in Figure 17-19c will necessarily have a stress and strain imparted thereto via the sutures held thereby, such plate may dissipate the stress and strain over a larger surface area via the incorporate of such tension spreading mechanism. As per the  
15 anchor plates themselves, such tension spreading mechanism may be formed from an absorbable or non-absorbable material and may be formed integral with or separate from the anchor plate.

Referring now to remaining drawings 9-15, and initially to Figure 9, there are depicted further embodiments of the present  
20 invention that are directed to devices for attaching sutures, grafts, tissues and the like to periosteum 36 (i.e., the thick fibrous membrane covering the surface of bones), as well as other types of soft tissue. In this regard, each of the embodiments herein preferably do not penetrate or otherwise  
25 become embedded within the bone 38, but rather are attachable to the periosteum 36 at a specific site thereof. However, it should be expressly understood that such embodiments may be modified or otherwise adapted to penetrate and become embedded within the bone 38, as may be necessary or ideal for a given  
30 medical procedure.

As will be appreciated by those skilled in the art, a wide variety of surgical procedures requiring fixation of sutures, grafts and the like, such as transvaginal sling surgery,

particularly when performed in accordance to the procedure depicted in Figures 1 and 2, frequently do not necessitate the use of devices, such as those depicted in Figure 5, that must necessarily be screwed or anchored within the bone. Quite unexpectedly, it has recently been reported at a meeting sponsored by the American UroGynecologic Society that by utilizing the periosteum 36 as a point of affixation, such affixation can be made more or equally secure than prior art bone screws and anchors, but at the same time achieving satisfactory, if not superior, structural support. In this regard, deployment of such prior art bone-screw/anchor devices is generally considered an excessive measure insofar as such devices are known to frequently provide an excess amount of support than what is typically required or suitable for such particular purpose. However, due to the fact that no feasible alternative had been available until now, such bone screw and anchor devices are utilized, which can substantially complicate such surgical procedures as well as cause the patient to endure unnecessary trauma, possibly delayed recovery time, and possibly higher risk of infection.

In the first of such embodiments depicted in Figures 9 and 10, there is provided an affixation device 90 comprised of at least one, and preferably a multiplicity of piton members 92 mounted upon a base member. Each one of the multiplicity of pitons 92, which may take the form of a hook as shown, is designed to ensnare with and become embedded in a target site of soft tissue of the periosteum 36, as depicted in Figure 9, but not penetrate or otherwise disrupt the outer surface of the bone 38 therebeneath. In this respect, the piton members 92 may be designed such that with light pressure the same only penetrate within a certain limited depth of the periosteum 36 or tissue, such that the same provide a moderate degree of fixation and can be easily removed, or with greater pressure the same penetrate



deeper so that the device 90 can become more securely embedded within the periosteum 36 or tissue to thus provide for a more secure base or attachment. Formed on the base member 94 is an attachment means, which may comprise a post or eyelet 96 as shown, to which may be attached the suture 98 or graft. As will be appreciated, the affixation device 90 need only be placed against the periosteum 36 at a target location such that the piton members 92 thereof become embedded there within. Because the piton members 92 of the affixation device are caused to only become embedded within the periosteum 36, such novel fixation device may be easily removed and repositioned as may be necessary in a given surgical procedure to insure that an optimal degree of support or positioning is attained.

Once so optimally positioned, the suture 98 or graft may be attached to the device 90 as per conventional surgical procedures. Alternatively, due to the ease by which the affixation device 90 may be detached and reattached, the surgeon is provided with the option of securing the suture 98 or graft to such affixation device 90 and thereafter positioning the affixation device 90 at a target site for best positioning. Advantageously, although the affixation device 90 is specifically designed to provide for easy dislodgment and repositioning, it is believed that once the same is secured into position, due to the eventual overgrowth of tissue about such device 90, the affixation device will continue to provide firmer and stronger support over time.

Referring now to Figures 11-13, there is shown a second embodiment 100 of an affixation device useful in the attachment of sutures, grafts, tissues and the like to periosteum, soft tissue, and bone. In the embodiment shown, such affixation device 100 comprises a tack member having a hub portion 102 and at least one, and preferably two or more, prong members 104 formed thereon. As illustrated, the implantable tack 100 may be

utilized to affix a graft 106 or other like tissue to the periosteum 36 by merely interposing the graft 106 between the periosteum and the tack 100 and compressing such tack 100 there against such that the prongs 104 thereof extend therethrough and become embedded in the periosteum 36 as systematically shown in Figures 11 and 12.

As will be recognized, the prong portions 104 of such tack 100 will be specifically designed and configured to extend through a given layer of tissue or graft material 106 and become embedded into the periosteum 36, but not otherwise extend to or penetrate the bone 38 lying therebeneath (although the embodiment may be modified for such applications). It will further be appreciated that such prongs 104 may vary in number and may take any of a variety of shapes and configurations necessary to achieve that end. As discussed above, it is contemplated that the prong members 104 may be designed to penetrate within the soft tissue, periosteum 36, or even bone 38 at specified depths to thus provide for selective degrees of attachment thereto. In this regard, it is specifically contemplated that such prong members 104 may be formed to have a straight, hook or arcuate shape such that the same facilitate the affixation of a graft 106 to the target site of fixation. For example, in Figure 12 it will be recognized that due to the arcuate shape of the prong members 104 of the implantable tack 100, when a force is applied in a direction indicated by the letter "I", such force will actually cause the prong members 104 of such implantable tack 100 to penetrate further within the periosteum 36 to thus cause the affixation to become more secure with increased tension. Furthermore, by utilizing a hub member 102 as part of the implantable tack 100, as illustrated in Figure 13, such implantable tack 100 can be easily accessed and removed in later surgical procedures. To facilitate such removal, a grip, protrusion or an aperture formed upon the hub

may be provided. For example, it is contemplated that an attached material, such as a synthetic mesh "extension" or sleeve, may be formed upon the hub 102.

Referring now to Figures 14 and 15, there is shown yet another preferred embodiment 110 of the present invention that comprises a novel surgical staple for securing sutures, tissues or grafts 112, to the periosteum 36. As illustrated, the staple 110 is operative to penetrate through a segment of tissue or graft 112 and become embedded within the periosteum 36 such that the graft or tissue is caused to become affixed therewith. As illustrated in the top view portion of Figure 14, the staple is operative to assume a first insertion configuration whereby the prongs 110a, 110b of such staple 110 are advanced through the graft 112 and ultimately into the periosteum 36. Thereafter, as illustrated in the top view of Figure 15, the prongs 110a, 110b are caused to embed within the periosteum 36 to enhance the attachment therewith. As may be necessary for a certain application, such prongs 110a, 110b may even be caused to embed within the bone 38 lying there underneath to thus provide a more secure attachment.

To facilitate the ability of the staple 110 to secure the graft 112 to the periosteum 36 in the aforementioned manner, it is contemplated that such staple 110 may be formed of resilient, self-expanding or self-contracting material which is biased to the operative configuration shown in Figure 15 such that when unconstrained, the opposed ends of the staple 110 will become further embedded into the periosteum. Similarly, such staple may be fabricated from a plastically deformable material which is initially formed to assume the insertion configuration depicted in Figure 14, but can subsequently be deformed to assume the operative configuration depicted in Figure 15. As a still further alternative, such staple 110 may be formed from a shape-memory material, such as nitinol, which thus enables the

staple to assume the insertion configuration depicted in Figure 14 when at room temperature, but transition to the operative, more secure configuration depicted in Figure 15 when warmed to body temperature, as will occur such staple is deployed. As a further advantage, to the extent it becomes necessary to remove or otherwise reposition such staple 110, it will be recognized by those skilled in the art that removal of such staple 110 may be facilitated by merely cooling the same down by any of a variety of well-known methods, including applying cold saline thereto.

All of the affixation devices discussed herein, although having widespread applicability and substantial advantage over prior art anchor devices, and more particularly bone screws and bone anchors, are particularly well suited in gynecologic and urologic surgical applications. It is believed that such affixation devices are particularly well suited for transvaginal sling surgery insofar as much of the medical literature tends to indicate that in a vast majority of patients, the sling that is utilized in such procedures should be placed with little to no tension at all, with the tension vector emanating therefrom being oriented in a direction well-suited to the piton portion of those embodying as depicted in Figures 6-8. Indeed, considerable authority exists that optimal placement of the sling in transvaginal sling surgery occurs when the sling merely comes into contact with the urethra. Affixation by attaching the sling merely to the periosteum and not to the bone is thus believed to provide more than sufficient leverage or support to the sling in such applications, but yet have the further advantage of being exceptionally easy to secure and re-secure into position in a much less traumatic manner than the prior art devices.

Although the invention has been described herein with specific reference to a presently preferred embodiment thereof,

it will be appreciated by those skilled in the art that various, modifications, deletions, and alterations may be made to such preferred embodiment without departing from the spirit and scope of the invention. For example, it will be recognized that the

5    piton portion of any of the surgical implants disclosed herein may take any of a variety of forms such that the same are caused to become more thoroughly seated in a position via the application of force in one direction, but yet become more easily withdrawn when pulled rearwardly in a second direction.

10   It is further contemplated that such embodiments may be formed from plastically deformable or shape-memory materials to thus facilitate fixation of such devices at a selected target site. Moreover, it should be recognized that the affixation devices disclosed herein designed to affix sutures, grafts, tissues,  
15   synthetic materials, and the like to periosteum may further be modified so that the same additionally penetrate into and become embedded within the bone lying thereunderneath. Specifically, with respect to the embodiment depicted in Figure 10, one or more of the hooks may be sized and adapted to penetrate into the  
20   bone, similar to the prongs formed on the implantable tack depicted in Figures 11-13. Likewise, the prongs of the staple element depicted in Figures 14 and 15 may be designed to penetrate and embed within the bone. Accordingly, it is intended that all reasonably foreseeable additions,  
25   modifications, deletions and alterations be included within the scope of the invention as defined in the following claims.